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Inside Tech Transfer

A technology transfer newsletter published by the Department of Energy's National Petroleum Technology Office

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News Beat

"Breakthrough Technology" Product of DOE-Industry Project;

New Wireline Logging Tool Available to Industry

1984 — DOE funded ParaMagnetic Logging, Inc.(PML) to develop basic concept; 3 subsequent grants awarded

1988 — Gas Research Institute (GRI) joins research effort

1989 — First patent granted; a total of 27 U.S. and foreign patents have resulted from this work

1994 — GRI and Western Atlas Logging Services begin work together

1995 — Schlumberger and Western Atlas Logging Services license the technology

1997 — Baker Atlas (formerly Western Atlas) purchases ParaMagnetic Logging, Inc. and its intellectual property

1999 — Technology ready for commercialization

A *"breakthrough technology"* made possible by the Department of Energy (DOE) through a grant to a Seattle-based engineering firm, **ParaMagnetic Logging, Inc.** in 1984, is now available to the oil and gas industry through commercial petroleum service companies. The device developed by the small firm in cooperation with DOE, GRI and a consortium of industrial companies measures formation resistivity behind the metal casing of wells making it possible to find oil "through the pipe."

Why is this important? In the United States alone there are several hundred thousand cased wells that are close to abandonment because of declining production. Some of these older wells may have undetected oil and gas behind pipe. There may be several reasons for this to occur: during the original drilling of the well, oil and gas may be flushed back into the producing formation due to a combination of mud weight and drilling practices used at the time. During openhole logging it is possible that the tool was unable to sense the presence of these hydrocarbons because the depth of penetration of the logging tool was not

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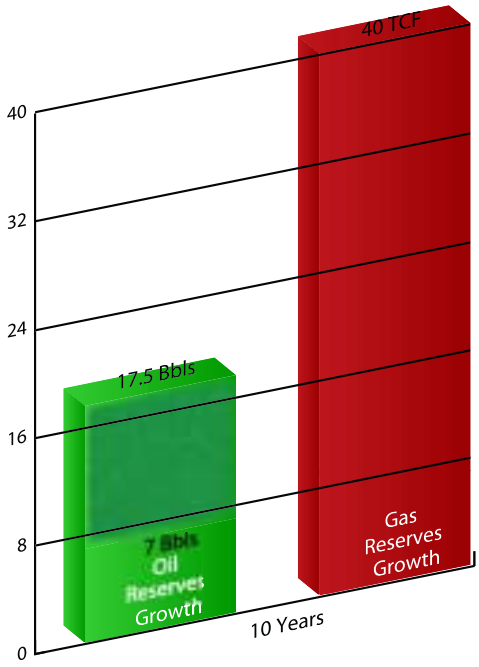
deep enough into the formation to contact the oil and gas that had been pushed away from the wellbore. Thus the operator may have cased the hole and drilled for a deeper target, not knowing that he was leaving reserves uphole. Once the well is cased and cemented, the formation fluids and gas can equilibrate back against the casing with time and now may become detectable using the through casing resistivity tool technology.

In other situations, wells that were originally drilled in the 1930s - 1960s may have encountered gas in shallower horizons but since there was little economic incentive to produce it, operators often cased and cemented through the gas interval and drilled deeper looking for oil. With many of these older wells changing hands numerous times through the subsequent years, most of the original openhole log data has been lost and the current operator may not be aware that he could have additional uphole potential that could lengthen the economic life of the well, if he was to recomplete uphole in the forgotten gas zone. This new technology has the potential to identify such zones through casing. There are many fields where older wells should be checked for uphole potential using this new technology prior to plugging and abandonment.

Thin bed effects have continued to offer challenges to log analysts interpreting openhole wireline logs. Many thinly bedded clastic formations contain hydrocarbons, but due to the averaging of the response of the openhole logging tool, the interpreter may conclude that zone is uneconomic. This effect, in combination with flushing of formation fluids away from the wellbore during drilling, may cause the openhole logging tool to give a false reading or at best a very pessimistic reading for these thinly bedded horizons. There is a possibility that this new technology may give a more accurate reading of the resistivity of these thinly bedded horizons once the well is cased and the fluids have a chance to equilibrate back up against the pipe.



Reserves growth with new technology.

Formation resistivity may actually change during EOR activities conducted in an oil field. These resistivity changes can be monitored periodically to give the operator a handle on what is going on in the subsurface during production and injection operations. Field managers may modify the injection and production rates, "change out" wells or even reverse injection directions to improve sweep efficiency and better manage the field to extend the life of the field and extract an incremental amount of the remaining oil in place. This can be particularly important since most oil fields are abandoned with as much as 60 to 80% of the original oil in place, still in the ground.

This advanced technology renders the pipe "transparent" so oil and gas producers can revisit existing wells and look for those undetected reserves. The device eliminates the need to drill expensive, time-consuming new wells, and encourages the production of new supplies of oil that otherwise would be considered uneconomical.

Who will benefit? Both majors and independents will benefit from the technology. The nearly 24,000 independents in the United States drill 85% of the nation's wells in 33 states, and account for 60% of the natural gas and nearly 40% of the oil produced in the U.S. Though a conservative estimate, implementation of the through casing resistivity logging tool has the potential to recover 2-5% of the

350 billion barrels of oil discovered, but unrecovered using present technology. This should add at least 7-17.5 billion barrels of oil to the reserves. Successful commercialization of the tool will help in the addition of some 40 Tcf of natural gas to the reserves out of an estimated 400 Tcf of new natural gas reserves to be found in and around existing fields in the United States.

What is the leading use? The leading use of the technology will be in enhanced oil recovery (EOR) projects such as in Phillips' fields in Alaska, secondary recovery fields in West Texas, and in steam flooding projects in California. The primary providers of this service will be logging companies such as Baker Atlas and Schlumberger

What are the economic benefits? If only a minimum of 7 billion barrels of oil are added to the reserves, this will generate an estimated 19.0 and 27.0 billion dollars in royalty and tax incomes. The addition of at least 40 Tcf of gas reserves will also generate 17.0 and 23.0 billion dollars in royalty and tax incomes, respectively.

Impacts–The commercialization of this technology produces numerous benefits for the industry:

Additional Reserves: As a result of the increasing costs of exploring and drilling for new oil and gas reserves, producers in the United States are focusing their efforts on improved recovery techniques to enhance production from existing reservoirs. One such approach is to carefully evaluate fields for infill drilling opportunities or untapped zones hidden behind casing. This technology lowers the risk while improving the recovery rate of previously undetected oil and gas reserves. As a result, this technology could substantially increase petroleum reserves.

Slowing Abandonment of Fields: Innovations such as this can extend the life of mature fields, thus reserves are added with little environmental impact, decommissioning costs are deferred, jobs are preserved, infrastructure is retained, and the window for new technology development is extended.

Cost Savings: Using this technology in conjunction with measurement while drilling, wells could be drilled and casing set without using open-hole logging tools, thereby minimizing the risk of losing the wellbore. Lost-hole costs are substantial as drilling costs can vary from less than $100,000 for shallow onshore wells to more than $15,000,000 for deep water Gulf of Mexico wells. The average U.S. cost to drill a 5000-ft oil well is $351,000.

Additional Research: Baker has scheduled testing of their research tool at a number of different locations including a number of wells in Conoco's California fields. Halliburton and Schlumberger have each funded major through casing research. Schlumberger has performed 16 field tests in the Middle East using their new casing profile tool.

Summary–ParaMagnetic Logging, Inc. designed and built two generations of experimental tools for measuring the resistivity of an underground formation through a metal casing. PML conducted engineering studies and produced proof-of-concept apparatus. The second-generation apparatus was successfully tested in well #2 at the MWX test site near Rifle, Colorado. In 1993 Baker Atlas conducted an extensive feasibility study. Subsequently, Baker Atlas entered into a licensing agreement with PML and began to develop commercial instrumentation in cooperation with a consortium of oil companies led by GRI. In 1997, Baker Atlas purchased ParaMagnetic Logging and its intellectual property.

A cased-hole formation resistivity prototype logging tool has been run successfully in numerous wells in different environments around the world. Application of this new measurement technology includes reservoir monitoring in low-porosity or low-salinity formations, formation evaluation when unstable well conditions have prevented the acquisition of openhole logs, and the identification of bypassed hydrocarbons.

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DOE-The University of Tulsa to Tackle Wax Accumulation in Deepwater Pipeline

A new project between the U.S. Department of Energy (DOE), the University of Tulsa (TU) and 14 private companies will tackle the problem of wax accumulation in deepwater pipelines using one of the world's most highly instrumented "flow loop" test facilities.

The DOE will provide $1.2 million in research funds from its Fossil Energy petroleum technology program. TU and its industry partners will add another $1.3 million for the 3-year project.

Virtually all crude oils contain long-chained molecules of wax in proportions that can vary up to as much as 60% of the crude oil's weight. In refineries, the paraffin wax can be separated and sold as commercial product. But in a pipeline or a wellbore, especially where temperatures are cold such as in the offshore waters of the Gulf of Mexico, the paraffin can deposit along the inside walls of the pipe, restricting its flow, increasing the strain on pumping equipment, or in the worst cases, shutting off production or causing a rupture in the pipe and accidental release into the environment.

Remediating pipeline blockages in water depths of around 400 meters can cost a million dollars or more per mile.

The new TU project will begin by enhancing computer models developed in prior DOE projects.

Tulsa University's million dollar flow loop to conduct paraffin deposition tests with crude oil and natural gas mixtures for DOE and 20 oil and gas companies. (single phase loop shown here).

Previous experiments using TU's flow loop testing facilities confirmed that a much broader collection of experimental data, including other oil samples, is necessary to develop more accurate methods for predicting the complex processes of paraffin deposition.

Researchers will flow a variety of crude oils and oil/gas mixtures through the test loop to improve understanding of the physical properties of paraffin and the mechanisms that control its accumulation. Using data from these experiments, computer programs developed in prior projects for predicting paraffin buildup will be enhanced and tested against actual field data from operating pipelines.

TU's highly instrumented flow loop could also be used to test and qualify subsea measurement sensors that are being developed to detect deposit thickness in flow lines and pipelines. Better models and paraffin sensors could reduce or eliminate the need for costly duplicate pipelines that are required for round-trip "pigging" operations–the sending of a cylindrical "scraper" through the pipeline to remove paraffin from the pipeline walls.

Better computer models could also tell operators where to place safety valves to minimize the chance of failures because of paraffin fouling.

These an other improved methods of preventing and remediating paraffin accumulation could save billions of dollars per year in maintenance and repair costs, improving project economics of many marginal offshore Gulf of Mexico fields to where they could be produced. Taxes and royalties from the additional production could significantly increase the $6 billion in annual federal revenue derived from these operations.

Multi-phase flow loop.

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TU Contact: Dr. Michael Volk, The University of Tulsa, 918-631-5127, e-mail: **michael-volk@utulsa.edu**

Native American Tribes Benefit from Partnership with DOE

On November 30, 2000, the National Petroleum Technology Office (NPTO) showcased its Native American Program during closing ceremonies of the Department of Energy's (DOE) American Indian Heritage Month. The DOE program identifies the unique resources and experiences of individual tribes and responds to their needs. Research projects that address these needs by developing and demonstrating technologies are conducted in partnership with the Tribes. Excerpts of three projects showcased during the final program follow:

Fort Peck Assiniboine & Sioux Tribes, Lawrence M. Monson

Lawrence M. Monson is a geologist for the Minerals Resource Office, Assiniboine & Sioux Tribes, Fort Peck Reservation, Montana.

According to Mr. Monson, "In working with the tribes over the years, my greatest challenge has been acquiring data and information. The DOE-sponsored project has allowed me to accumulate additional data needed to complete the research goals for the project."

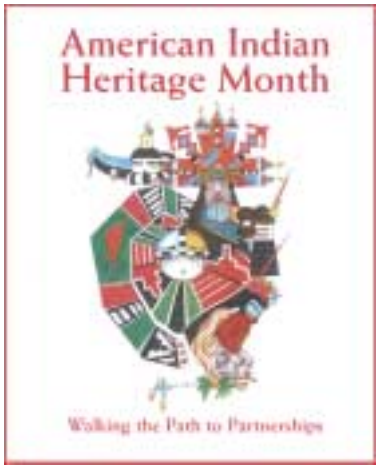
Assessment of hydrocarbon seepage on lands belonging to Fort Peck Tribes: Soil geochemistry application on aeromagnetic, Landsat lineament, and 3-D seismic anomalies on the Fort Peck Reservation, Montana

DOE teamed with Fort Peck Assiniboine & Sioux Tribes Mineral Resources Department, GCRIL Energy Ltd., Kipp Carroll, and George Shur. The Fort Peck reservation is relatively unexplored. However, it contains favorable structural and stratigraphic trends. During the first year of the project, researchers will evaluate at least five geochemical exploration methods over selected small producing fields, 3-D seismic anomalies, and photo-mapped surface lineament features that intersect aeromagnetic anomalies. In the second year, one or two of the most efficient exploration techniques will be applied to as many 3-D seismic and remote-sensing anomalies as possible across the northern portion of the Reservation. Those areas that look promising will be candidates for more intense exploration.

Osage Tribe, Rosemary Wood

Rosemary Wood has been an Osage Tribal Council Member since 1994. She is active in the Environmental Natural Resources Committee, the Health Committee, and the Finance Committee.

When asked about the Osage Tribe's relationship with DOE, Ms. Wood responded by saying, "We have been able to establish relationships that result in shared goals. By pulling in other partners, such as the Bureau of Indian Affairs and the United States Geological Survey, we are able to share



resources in cooperation and collaboration on a specific project. Through sharing, we all reach our goals and we all win."

Enhanced oil recovery with downhole vibration stimulation, Osage County, Oklahoma

A partnership was formed between DOE, Oil & Gas Consultants International, The Osage Tribal Council, Grand Resources, Inc. and Phillips Petroleum Company to test a downhole vibration tool in a newly drilled well as a method of stimulating oil production on the Osage Reservation in Oklahoma. The Osage Reservation is a mature oil producing region. Fields are under waterflood, but yield marginal production, generally less than ten barrels per day, and have substantial water production. Oil & Gas Consultants International and their research partners will test the impact of downhole vibration stimulation on production rates in

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Osage Reservation oil fields using a proprietary vibration core analysis system to calibrate the tool. Industry experience has shown that the technique works best in shallow reservoirs with high water content and medium-to low-viscosity oil. Osage County has a number fields with these criteria.

Panelists (from left to right) Lawrence Monson, David Lopez, Rosemary Wood, Chief Dee Ketchum, and NPTO moderator Rhonda Linsdey.

North Cheyenne Tribe, David A. Lopez

David A. Lopez is a Sr. Research Geologist with the Montana Bureau of Mines and Geology and specializes in regional and detailed geological mapping, structural, tectonic, and stratigraphic research in south central Montana.

When asked about the issue of trust when working in partnership with others, Mr. Lopez commented, "There is always an issue of trust. Our partnership is a 3-way one. When working with the federal government, there are issues related to treaties, and with the state there are other types of conflicts. We have established personal relationships with the tribes, so trust was established before this project began. It was easy to convince them to go ahead with the research. The personal one-to-one relationship is necessary in a partnership of this type. The tribes must feel as if we want to work with them."

Valley-Fill Sandstone in the Kootenai Formation on the Northern Cheyenne Indian Reservation

DOE formed a partnership with the Montana Bureau of Mines and Geology to evaluate oil and gas exploration prospects in the upper Kootenai Formation (Lower Cretaceous) and stimulate exploration on the Cheyenne Indian Reservation in south central Montana. Although the Greybull Sandstone produces oil and gas at the Mosser Dome field near Billings, Montana, production has not been established on the Northern Cheyenne Reservation. Geologic relationships and trends indicate oil and gas accumulations should be present on the reservation. This project identified at least four major valley systems with hydrocarbon potential. Drilling prospects were presented to industry in a workshop and field trip conducted in the fall 2000.

Panel Discussion Summary

DOE should pay attention to the individual needs of tribes and structure their approach to solicitations and other targeted programs in a way that takes the specifics of the groups into consideration. One size does not fit all Native American tribes.

- The tribes are concerned with making informed decisions rather than having decisions dictated to them.

- A personal relationship between the tribal members and the government offices that try to work with them is useful. This overcomes distrust and allows for clearer communication and trust to develop.

- Scientific data is something that is expensive for the tribes to obtain and sometimes they do not have the necessary expertise to acquire it. The DOE program has offered some very tangible benefits to the minerals management teams for several tribes.

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Who's Who

Meet Rita Bajura-Director, National Energy Technology Laboratory

Rita Bajura, Director of the National Energy Technology Laboratory

Rita A. Bajura is director of the **National Energy Technology Laboratory (NETL)**, a multi-purpose laboratory located in Morgantown, West Virginia, and Pittsburgh, Pennsylvania, owned and operated by the U.S. Department of Energy. In December 1999, Secretary of Energy Bill Richardson designated NETL as the Department of Energy's 15th national laboratory.

As director, Ms. Bajura oversees the implementation of major science and technology development programs in fossil energy and environmental technologies. These include:petroleum and natural gas exploration, production, and processing;advanced power generation technologies fueled by coal, natural gas, and biomass;environmental control technologies for the existing fleet of fossil steam plants; ultra-clean fuels for the transportation sector; and environmental technologies to clean up DOE's former nuclear production sites.

About 550 federal and 500 contractor employees work at NETL. Research and development activities are conducted both onsite and through partnerships and contractual arrangements with industry, universities, and other research organizations. The nearly 700 projects in NETL's portfolio are conducted at facilities in all 50 states and in several foreign countries.

Ms. Bajura has been director since 1996, and has been with the DOE since 1980. She has a master's degree in engineering from West Virginia University and a bachelor's degree in chemistry from Mercyhurst College in Erie, Pennsylvania. In 1997, the Governor of West Virginia appointed her to the State's Science and Technology Council. In 2000, she was inducted into the Academy of Distinguished Alumni of Mechanical Engineering and Mechanics at West Virginia University.

DOE's Tulsa Office Becomes Part of National Energy Technology Laboratory

On November 1, 2000, the **National Petroleum Technology Office** became an arm of the Department of Energy's newest national laboratory, the **National Energy Technology Laboratory**. The move to bring NPTO into the laboratory complex was a strategic one and elevates the DOE's petroleum research program to national laboratory status.

The action streamlines the process of technology development that benefits the Nation's domestic producers. The coordination between the petroleum technology program and the laboratory structure strengthens collaboration that leads to better technology exchanges between the oil exploration and production efforts of the Tulsa office with the natural gas researchers at NETL.

NETL is the Nation's 15th national laboratory and DOE's primary fossil fuel research center. The organization of NETL includes a new Strategic Center for Natural Gas and now the National Petroleum Technology Office. NPTO's 26-person staff will remain in Tulsa and will continue to coordinate the DOE's oil technology program.

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Resources

Meet Our Tech Experts…

If you are interested in meeting NPTO's technical staff, you can do so by stopping by the booth at any of the following meetings or go to the NPTO website at **www.npto.doe.gov:**

March

SPE, Society of Petroleum Engineers Production and Operations Symposium, March 24-27, 2001 in Oklahoma City, OK. Contact: Helen Bresson, 918/699-2014.

April

SPE, Society of Petroleum Engineers 2001 Hydrocarbon Economics and Evaluation Symposium, April 2-3, 2001 in Dallas, TX. Contact: Helen Bresson, 918/699-2014.

SPE, Offshore Technology Conference 2001: One World, One Event, Society of Petroleum Engineers, April 30-May 3, 2001, Astrodome, Houston, TX. Contact: Helen Bresson, 918-699-2014.

May

Marginal Well Commission Trade Fair, May 12, 2001, Tulsa Expo, Tulsa, OK. Contact: Helen Bresson, 918-699-2014.

June

AAPG, American Association of Petroleum Geologists Annual Meeting 2001: *An Energy Odyssey*, NPTO Booth No. 5600, June 3-6, 2001, Denver, CO. Contact: Helen Bresson, 918-699-2014.

Sites To See…

National Energy Technology Laboratory,
www.netl.doe.gov
The University of Tulsa, Paraffin Deposition Research,
www.tuwax.utulsa.edu
The University of Tulsa, Fluid Flow Projects,
www.tuffp.utulsa.edu